ME 6163: Combustion Engineering

Term Paper 01 Submission Date: TBA

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1. Methane, CH_4, is burned with dry air. The molar analysis of the products on a dry basis is CO_2, 9.7%; CO, 0.5%; O_2, 2.95%; and N_2, 86.85%. Determine (a) the air-fuel ratio on both a molar and a mass basis, (b) the percent theoretical air, (c) the dew point temperature of the products, if the products are cooled at 1 atm.

2. A natural gas has the following molar analysis: CH_4, 80.62%; C_2H_6, 5.41%; C_3H_8, 1.87%; C_4H_{10}, 1.60%; N_2, 10.50%. The gas is burned with dry air, giving products having a molar analysis on a dry basis: CO_2, 7.8%; CO, 0.2%; O_2, 7%; N_2, 85%. (a) Determine the air-fuel ratio on a molar basis. (b) Determine the air-fuel ratio on a mass basis. (c) Determine the percent of theoretical air.

3. One kilomole of carbon monoxide, CO, reacts with $\frac{1}{2}$ kmol of oxygen, O_2, to form an equilibrium mixture of CO_2, CO, and O_2 at (a) 1500 K, 1 atm, (b) 3000 K, 10 atm. Determine the equilibrium composition in terms of mole fractions.

4. Carbon dioxide at 25°C, 1 atm enters a reactor operating at steady state and dissociates, giving an equilibrium mixture of CO_2, CO, and O_2 that exits at 3200 K, 1 atm, Determine the heat transfer, in kJ per kmol of CO_2 entering.

5. Liquid Butane (C_4H_{10}) is sprayed into a combustion chamber. In addition, 400% theoretical air is supplied at an inlet temperature of 600 K. Gaseous products of combustion leave the chamber at 1100 K. If complete combustion is assumed, determine the heat transfer in kJ/kmol of fuel.

6. Liquid Butane (C_4H_{10}) at 25°C an 400% theoretical air at 298 K react in a steady-flow process. Determine adiabatic flame temperature assuming complete combustion.

7. Charcoal (wood char) is an easily made, high energy fuel that is lightweight and easy to transport. Assume that charcoal is composed of only C and consider the reaction of carbon with stoichiometric air to produce CO_2, CO, and O_2 at 2200 K and 2 atm. What is the volume fraction of CO when the products are in equilibrium at 2200 K due to the dissociation of CO_2?

8. Bituminous coal is burned to completion with 50% excess air. Find (a) the fuel-air ratio, (b) the volumetric analysis of the dry products. (c) the adiabatic flame temperature of this bituminous

coal. The as-received ultimate analysis of the coal is 70% carbon, 5% hydrogen, 15% oxygen, 5% moisture, and 5% ash on a weight basis.

9. Ultimate analysis of coal is given as: sulphur, 1.1; hydrogen, 4.4; carbon, 66.0; nitrogen 1.5; oxygen, 7.9; ash, 5.6; water, 13.5, in percent by mass. (a) Determine the reaction equation and air-fuel ratio used for complete combustion with 20% excess air. (b) If the products are cooled to 500 K, determine the heat transfer. (c) Estimate HHV and LHV of the coal sample.

10. One mole of CO and 1 mole of H_2O are heated to 2500 K and 1 atm. Determine the equilibrium composition, if it is assumed that only $CO, CO_2, H_2, H_2O \,\&\, O_2$ are present.